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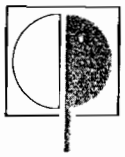

Field trials of pocket gopher control with cholecalciferol

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Cholecaliferol (Vitamin D_3) was evaluated as a field rodenticide for controlling pocket gophers (*Thomomys* spp.) under forest and seed orchard conditions by monitoring radio-equipped pocket gophers following the application of 0.0%, 0.003%, 0.04%, 0.075% and 0.15% cholecalciferol oat baits. In one trial, the difference in mortality of the three lower concentrations was not significantly greater than the control group. In two subsequent trials with the higher concentration (0.15%), mortality between the treatments was significantly greater than in the control groups. We recommend that primary and secondary hazards of cholecaliferol to nontarget species and predators be investigated.

Keywords: cholecaliferol; damage; rodenticide; *Thomomys*; toxicant

Pocket gophers are a major deterrent to reforestation on western forestlands (Borrecco and Black, 1990; Crouch, 1986). They also cause significant damage to other crops such as alfalfa (Luce, Case and Stubbendieck, 1981). Many forest managers and farmers have relied on baiting, using strychnine and diphacinone baits, to reduce gopher populations (Borrecco and Black, 1990; Evans *et al.*, 1990). Baiting is not without problems and usually provides only short-term control of gophers (Campbell *et al.*, 1992). The recent listing of several species (e.g. spotted owl, *Strix occidentalis*; black footed ferret, *Mustela nigripes*) under the Endangered Species Act has sharply curtailed the use of strychnine baits within the range of these species. Few efficacious and cost-effective alternatives to toxic baits exist. Trapping, although labor intensive, is being increasingly used as an alternative to baiting.

Cholecaliferol (Vitaming D_3) is registered (EPA Reg. No. 12455-39) for commensal rodent control (Brown and Marshall, 1988), and has shown potential for the control of field rodents (Tobin *et al.*, 1993). Pen trials suggest that the toxicant may have relatively low toxicity to some nontarget species, especially avian species (Marshall, 1984). Bell Laboratories, Inc., has applied to the EPA for a registration on cholecalciferol for the control of field rodents.

We conducted three field trials to test the efficacy of cholecaliferol oat baits with concentrations ranging from 0.0% to 0.15% cholecaliferol to control pocket gophers. The first trial involved hand baiting pocket gopher burrows on forest habitats in northeastern Oregon. The second and third trials involved hand baiting pocket gopher burrows within a forest seed orchard in northwestern Washington. Efficacy of the cholecalfiferol bait was determined by the mortality rate of radiocollared pocket gophers.

Study areas, materials and methods

Trial 1 was conducted in August–September, 1991, on four shelterwood (i.e. a small number of trees left after harvest) treatment units of the Wallowa–Whitman National Forest northeast of Baker City, Baker County, Oregon (T7S, R44E and T8S, R44E, Willamette Meridian). The study area 5.2 ha was occupied by the northern pocket gopher (*Thomomys talpoides*). Trials 2 and 3 were conducted in February–June, 1992, at the Washington Department of Natural Resources' Meridian Seed Orchard, Thurston County, Washington (T17N, R1W, Willamette Meridian). The 3.2 ha mowed field that had been forested until about 1985, was occupied by the mazama pocket gopher (*Thomomys mazama*).

During August 1991 and February 1992, pocket gophers were live-trapped, anesthetized with methoxyflurane, and 6 g radiocollars attached. A leg band was also attached to each animal in the February 1992 study for individual identifications in the case that the radiocollar was slipped or chewed off. Fully recovered animals were returned to their capture sites. Seventy animals were radiocollared for the first trial and 25 for the second trial. Nine remaining radiocollared control animals from Trial 2 were used for Trial 3. Each animal was relocated its activity determined for 2 consecutive days before baiting.

After baiting, animals were checked daily for activity. Animals found dead on the surface or underground by homing in on the radio signal were collected, weighed, checked for oat bait in their cheek pouches, and sexed

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before burial or incineration. If no activity by an animal was detected for 2 consecutive days, the carcass was found, excavated and examined as described above. During these activities, field personnel also looked for any carcasses of non-target animals on the surface. Animals still alive at the end of the field trials or with nonfunctional radio transmitters were recovered by live-trapping, euthanized and examined as described above.

Bait was prepared at the Denver Wildlife Research Center at 0.0%, 0.003%, 0.04%, 0.075% and 0.15% cholecalciferol concentrations using cholecalciferol concentrate (7.5% ai) provided by Bell Laboratories (Madison, WI, U.S.A.) and oat groats. The bait was analyzed (Method CHOLHPLC-4 by Motomoco Ltd. of Madison, WI, U.S.A.) to determine the concentration and uniformity of the mixture. Control bait was identical except that the cholecalciferol was omitted.

On 19 August 1991, pocket gophers at the Oregon units (Trial 1) were hand baited with cholecalciferol oat baits under field conditions with one unit each receiving 0.0% (control), 0.0003%, 0.04%, or 0.075% concentration baits. Each burrow system occupied by a radiocollared pocket gopher was baited. Baits were placed throughout all units on the same day. Five to seven shallow burrows per individual were opened, and each baited with about 8 g of bait using a long-handled tablespoon and closed, thus each burrow system received about 40–56 g bait. As each burrow system is generally occupied by one individual at this time of year, only the gopher with the radiocollar should be exposed to the baits in one burrow system. After baiting, no further human activity occurred on the treatment units until the next day, but cattle continued to graze throughout the test period.

On March 2 1992, 25 pocket gopher burrow systems were hand baited in Trial 2, where the field was divided into two roughly equal halves with 0.0% (control) cholecalciferol bait applied to one half (13 burrow systems) and 0.15% bait to the other (12 burrow systems). The baited areas were separated by about a 30 m buffer zone. Other baiting procedures were as described above.

Trial 3, also in March, 1992, used the nine surviving radiocollared control animals from Trial 2. The animals were divided into two groups and one group of five animals was randomly selected to be the treatment group. The 0.15% cholecaliferol oat bait for the treatment group was diluted 1:1 with untreated (0.0% cholecalciferol) oat bait before bait application to determine if a lower quantity of treated bait would be equally or better accepted and effective when mixed with untreated bait. Each of the five burrow systems received 40–56 g of oats, but only half of this material (20–28 g) was coated with the toxicant. The other group (four burrow systems each with one animal) became the control group and received 40–56 g of untreated bait. Bait was applied to the nine burrow systems on 17 March 1992. The animals in this trial had been pre-baited with untreated oat bait on 2 March 1992 (Trial 2).

Efficacy was determined by the formula shown at the top of the next column:

$$\% \text{ Efficacy} = \frac{\begin{array}{l}\text{No. of live animals}\\ \text{with functional radios}\\ \text{at day 1 (treatment day)}\end{array} - \begin{array}{l}\text{No. of live animals}\\ \text{with functional radios}\\ \text{at day 15}\end{array}}{\begin{array}{l}\text{No. of live animals}\\ \text{with fuctional radios}\\ \text{at day 1 (treatment day)}\end{array}} \times 100$$

For Trial 1, mortality data were analyzed for differences across concentrations, 15 days post-treatment, by use of Fisher's Exact Test. For Trials 2 and 3, mortality data were analyzed by the use of Chi-square tests of independence, comparing the percent of surviving versus dead radiocollared pocket gophers on the treated and control areas, 15 days post-treatment.

Results and discussion

There was no significant difference ($p > 0.1$) in efficacy across the range of treatments in trial one (*Table 1*). The low efficacy (≤50%) of these concentrations (up to 0.075% cholecalciferol) is not consistent with laboratory results (Tobin *et al.*, 1993). In the laboratory, 70% mortality was obtained with baits of only 0.003% concentration. There are several factors that may have contributed to these field results. The cholecalciferol concentrations or the amount of bait applied may have been too low, so that gophers were not exposed to adequate amounts of cholecalciferol. The feeding behavior of gophers may be involved: they do not normally ingest large amounts of bait in a single feeding, but rather consume small amounts of food frequently during the day (Lee *et al.*, 1990). In the field, a great many alternative foods are available which could result in reduced treated bait consumption; whereas, the laboratory studies were no-choice feeding trials. If gophers do not consume a lethal dose of cholecalciferol bait in the first feeding, they may become bait shy (Prescott *et al.*, 1992).

Another factor could have been competition for bait between gophers and other small mammals. At least one-third (range = 32–57%) of the bait placements on the four units in Trial 1 showed evidence of entry from outside by small mammals other than gophers, as

Table 1. Pocket gopher mortality determined by radiotelemetry 15 days after application of cholecalciferol oat baits under field conditions, 1991–1992

Species, site and trial	Conc. (%)	No. of gophers	Mortality (%)	Significance level
Trial 1:				
Thomomys talpoides	0.0	16	20	
Baker County, Oregon				
August 1991	0.003	16	12	$p > 0.1$
	0.04	17	50	
	0.075	17	50	
Trial 2:				
Thomomys mazama	0.0	13	8	
Thurston County, WA				$p < 0.01$
March 1992	0.15	12	92	
Trial 3:				
(as per Trial 2)	0.0	4	0	$p < 0.01$
	0.15*	5	100	

*The 0.15% oat bait was diluted 1:1 with control bait for the second trial; these animals were also pre-baited with untreated bait.

indicated by scratching and digging signs at bait spots shortly after baits were placed. Live-trapping later revealed the area to be occupied by least chipmunks (*Eutamias minimus*), heather voles (*Phenacomys intermedius*) and deer mice (*Peromyscus maniculatus*). Thus, the amount of bait that gophers were exposed to may have been greatly reduced. Mortality among the other three species remains unknown, but no small mammal carcasses were recovered during the course of the study. Three unrecovered radiocollars may have been the result of predation or radiotransmitter malfunction.

The 0.15% cholecalciferol oat bait in Trials 2 and 3 had a very high efficacy, which was significantly ($p < 0.01$) higher than the control groups (*Table 1*). It is interesting that the Trial 3 results (with treated bait diluted 1:1 with untreated bait) was as efficacious as the undiluted bait (Trial 2). However, because the treated bait animals in Trial 3 had, in effect, been pre-baited 2 weeks earlier (because they served as control animals in Trial 2), this result needs to be investigated further. In general, pre-baited rodents accept treated baits more readily (Lund, 1988). It is also possible that an intermediate concentration (0.1–0.125%) of cholecalciferol between our low-efficacy trial one and high efficacy trials two and three would also be efficacious. These two possibilities (diluted baits and intermediate concentrations) should be researched especially in light of the relatively high costs associated with cholecalciferol production (Cisse Spragins, Bell Laboratories, Inc., personal communication). Different species of pocket gophers were involved in Trial 1 in Oregon and subsequent trials in Washington, so the difference between Trial 1 efficacy (low) and Trials 2 and 3 efficacies (high) may be species-specific. Seasonal differences in food habits may have influenced the bait uptake in Trial 1 (August) Trials 2 and 3 (February–March). These factors also could be determined by additional research.

In Trials 2 and 3, most animals exposed to treated bait died quickly (4 days or less) and most died underground (at least 70.6%). However, four radiocollars were recovered above ground in Trial 2. Three of these collars were blood-stained and found at the base of a fence post along with raptor droppings and regurgitated pellets on the westside of the study field. In one case, a few small clumps of pocket gopher fur were also found. Staff had observed red-tailed hawks (*Buteo jamaicensis*) soaring in the general area and had seen one hawk perched on one of the wooden fence posts. Owls are presumed to hunt in the area at night. A fourth animal, the only radiocollared control animal to die during the two trials, was preyed upon (the chewed radiocollar being found about 120 m from the approximate center of the burrow system across a fence on a field). This animal may have been preyed upon by a mammalian predator as mammalian tracks (possibly of a canid or felid) were observed near the burrow system. Because four of 25 (16%) radiocollared animals in Trial 2 were consumed by predators, and perhaps three gophers in trial 1, we recommend studies to investigate the secondary exposure of predators from cholecalciferol-treated oat baiting.

Based on an open-hole method survey (Barnes *et al.*, 1970) conducted between 29 March, 1992 and 2 June, 1992, 22 of the 25 burrow systems (Trials 2 and 3) were active 10 weeks after Trial 3 concluded, indicating a high rate of re-invasion of burrow systems within two and a half months of having killed or otherwise removed the 25 original resident animals. Thus, the development of cholecalciferol bait for pocket gopher control should address the problem of rapid re-invasion.

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